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(81) Designated States (national): AE, AG, AL, AM, AT, AU,  
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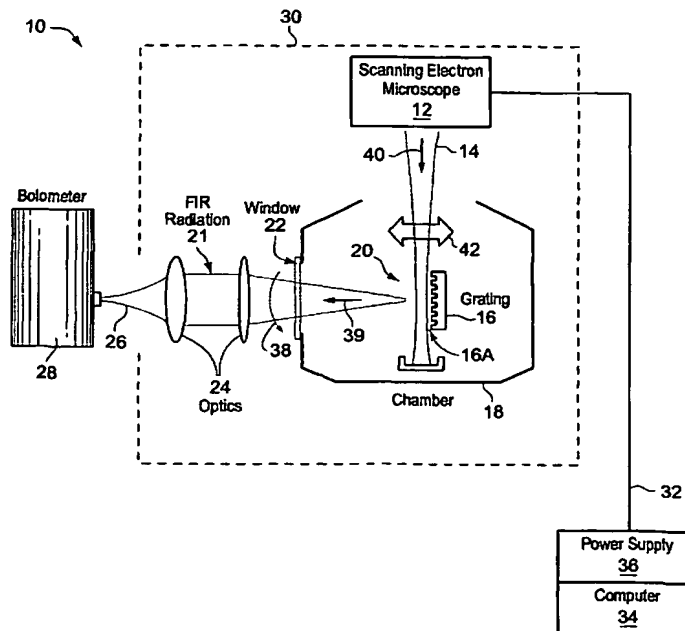
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KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
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GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

#### Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted  
a patent (Rule 4.17(ii)) for the following designations AE,  
AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH,  
CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES,  
FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,  
KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD,

[Continued on next page]

(54) Title: FREE ELECTRON LASER, AND ASSOCIATED COMPONENTS AND METHODS



(57) Abstract: A system generates FIR laser radiation. An electron source generates an electron beam. A grating horn interacts with the electron beam to produce the FIR laser radiation. The grating horn may comprise a flat base and a pair of grating elements attached to the base, each of the grating elements being ruled with a grating period, the grating elements oriented in phase and in substantial symmetry about a normal to the flat base.



MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

— as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ,

MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

— of inventorship (Rule 4.17(iv)) for US only

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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/30566

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01S3/09

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 263 043 A (WALSH JOHN E) 16 November 1993 (1993-11-16) cited in the application the whole document	1,2,11, 16,18
A	US 5 790 585 A (WALSH JOHN E) 4 August 1998 (1998-08-04) cited in the application the whole document	1,2,11, 16,18
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

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Authorized officer

Lendroit, S

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/30566

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WALSH J E ET AL: "A new far infrared free-electron laser"</p> <p>NUCLEAR INSTRUMENTS &amp; METHODS IN PHYSICS RESEARCH, SECTION - A: ACCELERATORS, SPECTROMETERS, DETECTORS AND ASSOCIATED EQUIPMENT, NORTH-HOLLAND PUBLISHING COMPANY. AMSTERDAM, NL, vol. 429, no. 1-3, 11 June 1999 (1999-06-11), pages 457-461, XP004171254</p> <p>ISSN: 0168-9002</p> <p>cited in the application</p> <p>the whole document</p> <p style="text-align: center;">-----</p>	1,2,11, 16,18
A	<p>URATA J ET AL: "Superradiant Smith-Purcell emission"</p> <p>PHYSICAL REVIEW LETTERS, 19 JAN. 1998, APS, USA, vol. 80, no. 3, pages 516-519, XP002277686</p> <p>ISSN: 0031-9007</p> <p>cited in the application</p> <p>the whole document</p> <p style="text-align: center;">-----</p>	1,2,11, 16,18
A	<p>BAKHTYARI A ET AL:</p> <p>"Amplified-spontaneous-emission power oscillation in a beam-wave interaction"</p> <p>PHYSICAL REVIEW E (STATISTICAL, NONLINEAR, AND SOFT MATTER PHYSICS), JUNE 2002, APS THROUGH AIP, USA, vol. 65, no. 6, pages 066503/1-4, XP002277687</p> <p>ISSN: 1063-651X</p> <p>cited in the application</p> <p>the whole document</p> <p style="text-align: center;">-----</p>	1,2,11, 16,18
A	<p>VAN DEN BERG P M: "Smith-Purcell radiation from a point charge moving parallel to a reflection grating"</p> <p>JOURNAL OF THE OPTICAL SOCIETY OF AMERICA, DEC. 1973, USA, vol. 63, no. 12, pages 1588-1597, XP009029663</p> <p>ISSN: 0030-3941</p> <p>cited in the application</p> <p>the whole document</p> <p style="text-align: center;">-----</p>	1,2,11, 16,18
A	<p>GOLDSTEIN M ET AL: "Demonstration of a micro far-infrared Smith-Purcell emitter"</p> <p>APPLIED PHYSICS LETTERS, 28 JULY 1997, AIP, USA, vol. 71, no. 4, pages 452-454, XP002277689</p> <p>ISSN: 0003-6951</p> <p>the whole document</p> <p style="text-align: center;">-----</p>	1,2,11, 16,18
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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 03/30566

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 268 693 A (WALSH JOHN E) 7 December 1993 (1993-12-07) the whole document -----	1,2,11, 16,18
A	US 4 874 953 A (KATZ JOSEPH) 17 October 1989 (1989-10-17) the whole document -----	1,2,11, 16,18
A	US 4 727 550 A (CHANG DAVID B ET AL) 23 February 1988 (1988-02-23) the whole document -----	1,2,11, 16,18

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US 03/30566

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-13, 16-18

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

## INTERNATIONAL SEARCH REPORT

International Application No. PCT/ US 03/ 30566

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-13,16-18

Diffraction grating element with specific transversal profile.

System for generating far-infrared laser radiation comprising this diffraction grating element.

Associated method of generating far-infrared laser radiation.

First underlying problem to be solved by independent claims (1,2,11,16,18) is to improve the grating element of a far-infrared laser radiation system.

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2. claims: 14-15

A system for generating far-infrared laser radiation comprising a plurality of gratings for tuning the wavelength of the radiation.

Second underlying problem to be solved by independent claim 14 is to realise a tunable far-infrared laser radiation system.

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 03/30566

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5263043	A	16-11-1993	AU 8718391 A WO 9204747 A1 US 5268693 A	30-03-1992 19-03-1992 07-12-1993
US 5790585	A	04-08-1998	AT 215274 T AU 5104698 A DE 69711419 D1 DE 69711419 T2 DK 939977 T3 EP 0939977 A1 IL 129880 A JP 2001504991 T WO 9821788 A1	15-04-2002 03-06-1998 02-05-2002 07-11-2002 15-07-2002 08-09-1999 21-04-2002 10-04-2001 22-05-1998
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